4 ATMOSPHERIC AND SURFACE POLLUTANT STUDIES RELATED TO GLOBAL CLIMATE CHANGE

4.1 OVERVIEW

Robert Leifer

Atmospheric and surface pollutant studies related to global climate change at EML primarily focuses on the interaction of aerosols in atmospheric radiative processes. Additional studies investigate transport mechanisms involving natural and anthropogenic tracers. Both anthropogenic and natural atmospheric aerosols can have a profound effect on the earth's radiation budget. Aerosols can absorb or scatter radiation that can modify the earth's albedo and climate. Aerosols play a vital role in the formation of clouds by acting as cloud and ice forming nuclei. The size, morphology and chemical composition together with physical and dynamic processes determine whether the aerosol will be involved in cloud production or the earth's radiation budget. The source of these aerosols is from the earth's surface where they are transformed by chemical and physical processes into particles that may ultimately affect our climate. For these reasons, investigations pertaining to the role of aerosols in atmospheric processes have become an important area of research at EML.

During the past year, EML's climate research involved the development of an operational aerosol observation system (AOS) for the Atmospheric Radiation Measurements (ARM) Program to help quantify the interaction of aerosols with direct or solar radiation. The AOS consists of a set of aerosol instruments which, when assembled, provide a detailed picture of the surface aerosol structure at the Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site. The Laboratory provided the engineering design and construction for a special support structure for the AOS. The AOS was installed at the SGP site in October 1995 and is undergoing extensive testing.

Since June 1991, we have continued to provide radon measurements at the Atmospheric/Ocean Chemistry Experiment (AEROCE) site at Tudor Hill, Bermuda, and since December 1990, at the National Oceanic and Atmospheric Administration (NOAA) Climate Monitoring and Diagnostics Laboratory's (CMDL) Mauna Loa Observatory (MLO). Radon observation at the sites provided a unique opportunity for researchers at the University of Maryland to validate 3-d chemical transport model.

EML completed its participation in Project Mohave in which perfluorocarbon tracers were released from potential sources of atmospheric pollutants to investigate the impact of these pollutants on the haze and visibility conditions in the Grand Canyon National Park.

4.2 AEROSOL OBSERVATIONS AT THE SOUTHERN GREAT PLAINS SITE: EQUIPMENT INSTALLATION AND OPERATION

Robert Leifer, Ronald. H. Knuth, Brian Albert, S. Frederic Guggenheim and Hsi-Na Lee

To meet the needs of the ARM program, EML has the responsibility to establish a surface aerosol observation system (AOS) at the SGP site. To minimize the impact of surface agricultural activities at and near the site, sampling of the ambient aerosol occurs at a height of 10 m. To facilitate sampling at 10 m, we have designed a special tilt down sampling stack and manifold for aerosol characterization. The stack is designed for both long-term use and easy maintenance. Figure 4.1a is a photograph of the stack and associated equipment. At the top of the stack is a rain hat containing a stainless steel screen to prevent birds and insects from entering the stack. The tilt down capability allows the screen on the ground to be changed safely and easily. EML provided all the drawings necessary for ARM management to solicit bids for construction of the outside support structure of the AOS. We fabricated the aerosol sampling stack and the stack support structures at EML. The stack support structures were shipped to a subcontractor in Oklahoma for installation at the CART site prior to the arrival of the EML instrument installation team.

The complete system was installed in five electronic racks at EML. This allowed us to custom design many of the specialized components of the AOS at EML and install them in the racks before shipment. After the system was completed and tested, it was completely disassembled and shipped to the SGP for installation in the aerosol trailer. Figure 4.1b is a view of the inside of the trailer showing the sampling inlets and racks.

Six instruments are included in the AOS: a single wavelength nephelometer (λ=530 nm), optical particle counter (OPC), condensation particle counter (CPC), optical absorption monitor (PSAP), a three wavelength nephelometer (λ =450, 550,700 nm) with back scatter capability, and an ozone monitor. The aerosol instruments are connected in a specially designed manifold (Figure 4.2). A 10 μm impactor limits the size of the aerosol reaching the nephelometer, PSAP and CPC. The OPC, which measures the size distribution, is connected through an isokinetic probe to the sampling line before the impactor.

The ozone monitor has its own teflon sampling line and is mounted adjacent to the aerosol sampling stack. As the tubing enters the trailer, a temperature controlled heater gently warms the inlet air to prevent condensation during the air conditioning season. Approximately 1000 L min^{-1} of air enters the stack at a height of 10 m. A heated sampling line inside the stack allows the removal of 150 L min^{-1} of air from the main air stream. This air stream splits into five 30 L min^{-1} streams. Four lines are for isokinetic sampling (particle size preserved in sampling) and one is a non-isokinetic line.

A field data ingestor (Sun Workstation) located in the aerosol trailer interrogates and controls the various instruments and components via RS-232 serial interface ports. In addition, the field data ingestor samples analog signals and performs control functions. We have been collaborating with Richard Eagan of Argonne National Laboratory, who is developing the software for the data acquisition system.

An operator's manual detailing the design and operation of the AOS was written and submitted to the Site Operations Office for approval prior to site personnel taking over the operational maintenance of the AOS.

Trajectory analyses are calculated twice daily for the ARM science team for the characterization of air mass types as they pass over the site. To improve the air mass classification, we are also including observations of the vertical temperature structure and amount of precipitation along the estimated trajectory to evaluate the modification of the upper air mass by local surface pollutants.

References

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Figure 4.1a Photograph of the aerosol trailer and sampling stack at the Southern Great Plains ARM site.

Figure 4.1b Photograph of the inside of the aerosol trailer.

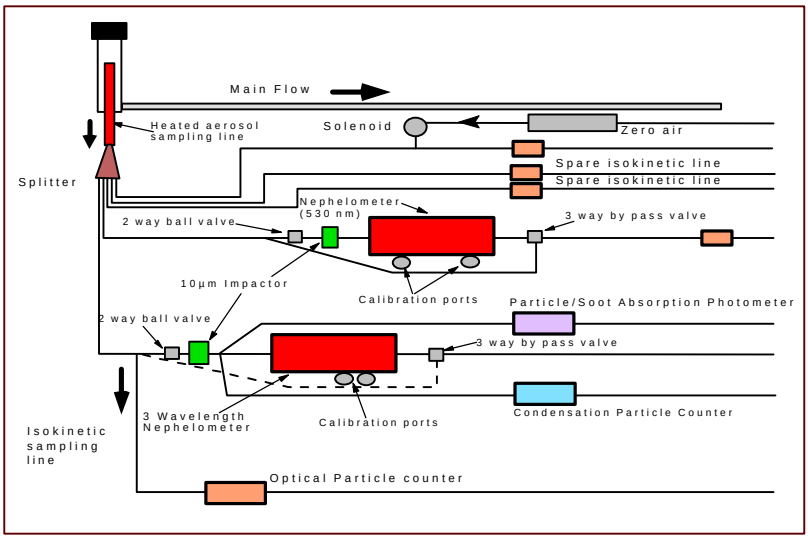

Figure 4.2 A block diagram of the aerosol sampling system (AOS) showing various sampling lines and the major components of the AOS. Air passes through a heated tube controlling the relative humidity of the air stream before splitting into 5 airstreams. Four of the airstreams are isokinetic and one is non-isokinetic.

4.3 ATMOSPHERIC TRACERS

Raymond J. Lagomarsino

Perfluorocarbon tracer concentrations from two-hour surface samples collected in the measurement of haze and visual effects (MOHAVE) experiment (July 1992) at Dolan Springs, AZ, have been transmitted to EPA, Las Vegas, as a database for the development/verification of atmospheric models of the experiment. MOHAVE was designed to determine if pollutants from the Los Angeles basin, El Centro, CA, and a coal-fired power plant located in Lauglin, NV, are transported to Grand Canyon National Park. A different perfluorocarbon tracer was released from each location to mimic the pollutant plume trajectories.

Vertical samples, which were simultaneously obtained with surface samples, were collected at altitudes of up to 500 meters above the surface with a multiport sampler (Polyport) attached to a tether line of a 7.25 m^3 balloon. Only 35% of the anticipated number of above-the-surface samples was obtained because (a) the balloon could not be launched when wind speeds exceeded 10 meters sec^{-1}; and (b) high winds which developed during the flight caused balloon instability. Also, because of weight considerations, no more than two Polyports could be lifted to the desired altitude. Generally, only one sampler was used during each balloon flight of 22 hours. Analytical results performed by EML for the vertical samples have now been completed, compiled and evaluated, and a final report will be sent to EPA, Las Vegas, in 1996.

Reference

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4.4 ATMOSPHERIC RADON MEASUREMENTS AT BERMUDA AND MAUNA LOA, HAWAII

Adam R. Hutter and Richard J. Larsen

The EML radon analyzer, installed at the Atmospheric/Ocean Chemistry Experiment (AEROCE) site at Tudor Hill, Bermuda, in June 1991, and at the National Oceanic and Atmospheric Administration (NOAA) Climate Monitoring and Diagnostics Laboratory's (CMDL) Mauna Loa Observatory (MLO) in December 1990 continued to provide high quality useful radon measurements during 1995. A paper was published in 1995 summarizing our radon analyzer and the applicability of the data to air mass provenance determination (Hutter et al., 1995). Additionally, the radon data, when coupled with meteorological data (obtained by Dr. Hal Maring, University of Miami at the AEROCE site, and the CMDL staff at the MLO), provides the scientific community with a unique and comprehensive database which can be used for the validation of atmospheric transport models. For example, the data was recently used by Dr. Dale Allen, University of Maryland, to validate a 3-d chemistry and transport model (Allen, 1996) and by Dr. Natalie Mahowald, National Center for Atmospheric Research (NCAR), to evaluate global chemical transport models (Mahowald, 1995).

The quality of the radon measurements was demonstrated during the first international intercomparison of atmospheric ^{222}Rn analyzers (Colle et al., 1995a; 1995b). The results of the intercomparison indicated the EML analyzer produced radon values that averaged less than 10% different from the NIST standard radon additions (Figure 4.3).

In the future, our radon analyzers will continue to provide a high quality, unique and timely database for validating and evaluating global climate models. Additionally, we are currently evaluating the deployment locations of the radon analyzers.

References:

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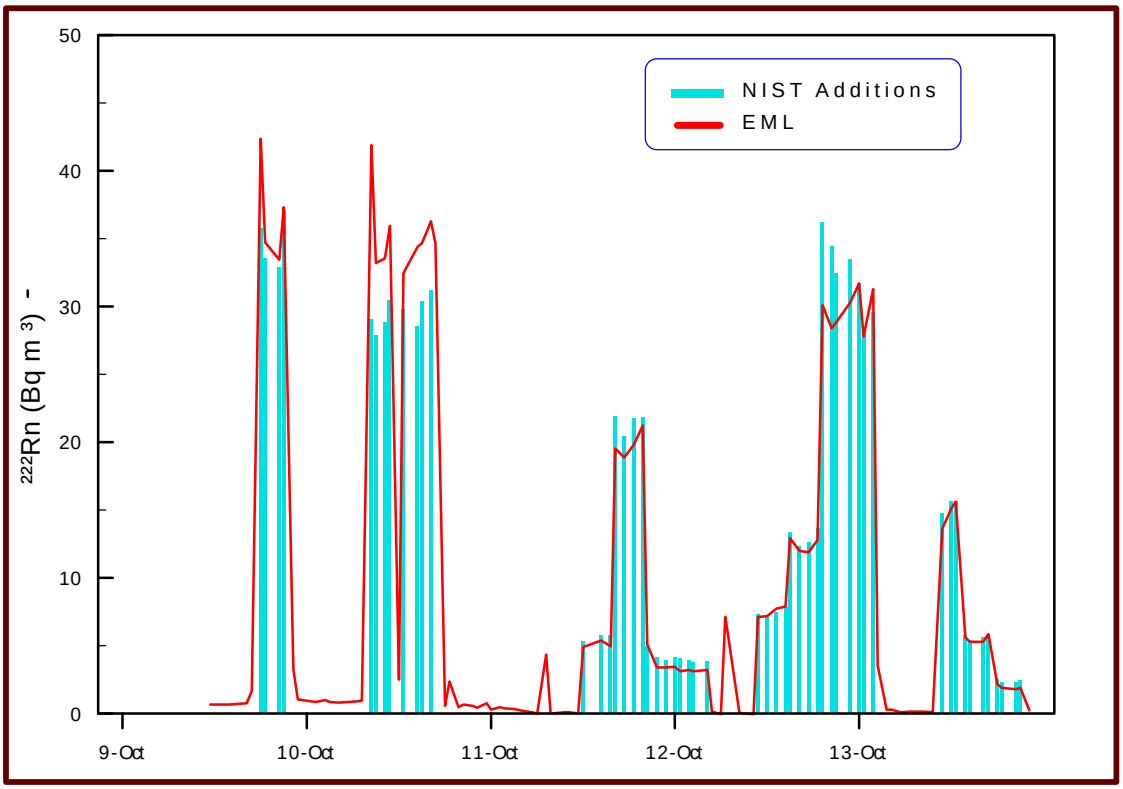

Figure 4.3 The results of the International Intercomparison of marine-atmospheric ^{222}Rn measurements showing EML's results and the NIST standard additions. The arithmetic mean difference for all the measurements between the NIST and EML values is ~ 9%.